REMARKS/ARGUMENTS

Amendment of the Specification

Applicant thanks the Examiner for his careful attention to this case, and for providing detailed comments on the amendments, even though the amendments were not entered. As to some of the Examiner's objections, Applicant has, in the interests of speedy prosecution, made amendments to overcome the objections; Applicant reserves the right to dispute those objections in a continuing application. As to the other objections by the Examiner, Applicant has pointed to disclosure in the original PCT application which, it is believed, clearly shows that the objections should be withdrawn.

The following remarks are made by reference to the numbered paragraphs of the Substitute Specification.

00001-00004

It appears that there are no issues arising on these paragraphs.

00005

A. The Examiner objected that there was no support for stating that the invention provides "improved insulation" or "an improved balance of wire-performance characteristics". These phrases have been removed. The paragraph now states that the invention "makes it possible to achieve high-performance bonding between the layers while retaining an acceptable balance in the complex relationships of other wire performance requirements". This wording is based on Page 1, lines 5-8, of the PCT specification which states

> *The invention is especially useful in multi-layer insulation of electrical wires, making it possible to achieve high-performance bonding between layers such materials while retaining an acceptable balance in the complex relationships of other wire performance requirements...*

B. The Examiner objected that there was "no support for the second layer comprising a selected fluoropolymer" and that the description of the first layer was "much broader than

originally disclosed". The first sentence of paragraph 00005 has been amended to remove the references to a "selected" carbonyl-containing polymer and a "selected" fluoropolymer, and instead to refer explicitly to first and second polymeric compositions "as defined below".

00006-00007

A. The Examiner objected that the "original disclosure only supports carbonyl-containing polymers that have non-aromatic backbones". In these paragraphs, and throughout the specification and claims, the carbonyl-containing polymers are now defined as having non-aromatic backbones.

B. The Examiner objected that the original disclosure "does not have support for the weight percentages wherein the weight percentages are based on 'the weight of the first polymeric component (or, in some embodiments, based on the weight of the whole composition)'" and that the original specification "only has support for embodiments wherein the weight is based upon the weight of the whole composition". It is submitted that these objections should be withdrawn. The Examiner's attention is drawn to claim 2 of the PCT specification, which states that the amount of the carbonyl-containing polymer is at least 20%, preferably at least 40%, more preferably at least 60%, very preferably at least 80%, of the **weight of the polymeric portion** of the said formulation; the same disclosure is to be found on page 3, lines 12-15 of the PCT specification. Claim 1 of the PCT specification, by contrast, bases the weight of the carbonyl-containing polymer on **the weight of the entire composition**.

The "first aspect" of the invention and corresponding claims 28-33, 37-40, 42, 46-54, 68-70, 72 and 73, follow the definition of PCT claim 2 (and PCT page 3, lines 12-13) and base the weight of the carbonyl-containing polymer in the first polymeric composition on **the weight of the polymeric component** of the first polymeric composition. The "second aspect" of the invention, and corresponding claims 57-67 and 71, follow the definition of PCT claim 1 (and page 2, lines 20-21) of PCT specification, and base the weight of the carbonyl-containing polymer in the first polymeric composition on **the weight of the entire first polymeric composition**.

C. The Examiner objected that there is no support for the limitation that the second polymeric component comprises at least 90% by weight based on the weight of the second polymeric composition of polyvinylidene fluoride or the specified vinylidene fluoride copolymer. It is submitted that this objection should be withdrawn. The Examiner's attention is drawn to the disclosure on PCT page 2, line 32, to page 3, line 2 (*a second layer of a material containing at least... 90% by weight of polyvinylidene fluoride (PVDF), or especially preferably a copolymer based on VDF with a partially or fully fluorinated comonomer*) and to the similar disclosure in the PCT Abstract on page 17, line 16.

D. The Examiner objected that there is no support for "substantially 100%", but observed that there is support for "100%". In these paragraphs, and elsewhere in the specification, "substantially 100%" has been replaced by "100%".

E. The Examiner objected that there is no support in the original disclosure for the newly added second and third aspects of the invention. The Examiner did not provide any detailed reasoning in support of this objection.

This Reply does not request entry of the previously-proposed third aspect of the invention. Applicant submits that the objection to the second aspect of the invention should be withdrawn. The first and second aspects of the invention, as they are set out in the Substitute Specification, are presented below (in italicized text) with annotations to show the basis for them in the PCT specification. It is believed that the Examiner, after considering this presentation, will agree that the first and second aspects of the invention do not add any new subject matter to the PCT specification.

[00006] In a first aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, ***[PCT page 9, line 6 (pub PCT, page 10, line 6)]*** *and*

2) insulation comprising ***[PCT page 13, line 20 (pub PCT, page 14, line 20)]***

(i) a first layer which is composed of a first polymeric composition consisting of a first polymeric component and optionally a first additive component, ***[PCT page 4, line 11-12 (pub PCT, page 4, line 13-14)]*** *the first polymeric component comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric component of a carbonyl-containing polymer****[PCT page 3, line 10-14 (pub PCT, page 3, line 13-15 and PCT claim 2)]*** *which has a non-aromatic backbone* ***[PCT page 2, line 24 (pub PCT, page 2, line 26), and, in the interests of speedy prosecution, accepting the Examiner's statement that the PCT disclosure "states that the carbonyl containing polymer is an olefinic polymer, which excludes aromatic backbones".]*** *and which may be a homopolymer or copolymer including terpolymer,* ***[PCT page 3, line 15 (pub PCT, page 3, line 16)]*** *, the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer****[PCT page 3, line 21 (pub PCT, page 3, line 22) and PCT claim 2]*** *and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate),* ***[PCT page 3, line 16-18 (pub PCT, page 3, line 17-19) and PCT claim 2]*** *the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% ,* ***[PCT page 3, line 18-19 (pub PCT, page 3, line 19-20)]*** *for example 15 to 28%,* ***[PCT Examples, in which the EMA copolymer at the bottom of page 7 (pub PCT page 8) contains 28% of said monomer, and all but one of the carbonyl-containing polymers contains 15-28 weight% of said monomer]*** *by weight of the carbonyl-containing polymer and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene;* ***[PCT page 3, line 20-21 (pub PCT, page 3, line 21-23)]***

(II) a second layer which is in direct contact with the first layer at an interface, ***[PCT page 3, lines 19 and 28 (pub PCT, page 10, lines 18 and 29) and PCT claim 19]*** *and which is composed of a second polymeric composition*

consisting of a second polymeric component and optionally a second additive component, ***[PCT page 4, line 15-16 (pub PCT, page 4, line 17-18)]*** *the second polymeric component comprising at least 50%, particularly at least 90%, for example 100%, by weight based on the weight of the second composition,* ***[PCT page 3, line 22-24 (pub PCT, page 3, line 25-27)]*** *of polyvinylidene fluoride (PVDF) or a vinylidene chloride (VDF) copolymer consisting essentially of*

(a) repeating units derived from vinylidene chloride, and

(b) repeating units derived from a partially or fully fluorinated co-monomer, preferably hexafluoropropylene (HFP);

*the first layer being positioned between the conductor and the second layer****[PCT page 5, line 21-22 (pub PCT, page 5, line 25-26)]****.*

[00007] *In a second aspect, this invention provides an insulated electrical wire comprising*

1) *a metallic conductor****[PCT page 9, line 6 (pub PCT, page 10, line 6)]****, and*

2) *insulation which comprises*

(i) a first layer which is composed of a first polymeric composition comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric composition, ***[PCT page 2, line 22-23 (pub PCT, page 2, line 13-15) and PCT claim 1]*** *of a carbonyl-containing polymer which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer,* ***[PCT page 2, line 23-24 (pub PCT, page 2, line 15-16) and PCT claim 1]*** *the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer****[PCT page 2, line 29 (pub PCT, page 2, line 31-32) and PCT claim 1]*** *and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%,****[PCT page 2, line 27-28 (pub PCT, page 2, line 29-3) and the PCT Examples, in which the EMA copolymer at the bottom of page 7 (pub PCT***

page 8) contains 28% of said monomer, and all but one of the carbonyl-containing polymers contains 15-28 weight% of said monomer] *by weight of the carbonyl-containing polymer, and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene,* ***[PCT page 2, line 29-30 (pub PCT, page 2, line 31-32)]*** *and*

(ii) a second layer which is in direct contact with the first layer at an interface, ***[PCT page 3, line 21 (pub PCT, page 2, line 32) and PCT claim 17]*** *and which is composed of a second polymeric composition comprising at least 50%, preferably at least 90%, for example 100%, by weight, based on the weight of the second polymeric composition,* ***[PCT page 2, line 31-32 (pub PCT, page 3, line 1-2)]*** *of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of*

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a partially or fully fluorinated comonomer, preferably hexafluoropropylene (HFP); ***[PCT page 2, line 30 (pub PCT, page 3, line 2-4)]***

the first layer being positioned between the conductor and the second layer.

[00008]

In response to the Examiner's request to state the support for this paragraph, this paragraph is reproduced below in italicized text with annotations to show the basis for it in the PCT specification.

[00009] A third aspect of the invention provides a method of making an insulated wire or cable, the method comprising the steps of

(A) providing an electrical conductor surrounded by

(i) a first layer which is composed of a first polymeric composition as defined in the first or second aspect of the invention; and

(ii) a second layer which is composed of a second polymeric composition as defined in the first or second aspect of the invention;

the first and second layers being in direct contact with each other at an interface, ***[PCT claim 17, lines 1-3]*** *and the first layer being positioned between the conductor and the second layer;* ***[PCT claim 9]*** *and*

(B) exposing the layers while in contact with each other to ionizing radiation which causes cross-linking of polymers at the interface. ***[PCT claim 11]***

00010-00011

It appears that there are no issues arising on these paragraphs.

00012-00013.

These paragraphs correspond to paragraph 35 (RCE), which the Examiner objected to as containing new matter, in that the additives listed on PCT page 10 specify the layer to which they are added. Appropriate changes have been made in the paragraphs set out in the Substitute Specification. Those paragraphs are set out below, in italicized text, and with annotations showing the basis in the PCT specification for them.

[00012] Each of the layers (i) and (ii) optionally contains, in addition to the polymeric component of the composition, an additive component to give it required properties. ***[PCT page 4, lines 10-12 and 15-16 (pub PCT page 4, lines 12-14 and 17-18)]***

[00013] Examples of additives which may be present in the first polymeric composition are cross-linking promoters, antioxidants, pigments, fillers, flame retardants, etc. as known per se. ***[PCT page 4, lines 14-15 (pub PCT page 4, lines 14-15) and PCT page 6, lines 11-12 (pub PCT page 6, lines 15-16)]***

Examples of additives which may be present in the second polymeric composition are cross-linking promoters, pigments, plasticizers, stabilizers, antioxidants and process aids. ***[PCT page 4, lines 15-16 (pub PCT page 4 lines 17-18), PCT page 6, lines 11-12 (pub PCT page 6, lines 15-16, and PCT page 9, lines 7-9)]***

00014

It appears that there are no issues arising on this paragraph.

00015

This paragraph corresponds to paragraph 39 RCE, as to which the Examiner objected that the last four lines were not supported by the PCT specification. It is submitted that this objection should be withdrawn. The Examiner's attention is directed to the following points.

(A) "The first layer can optionally be in direct contact with the conductor."

See PCT page 8, line 10, to page 9, line 25 (in particular, page 9, lines 5-6... noting that the polyolefin-based composition was "pressure extruded on to the metallic conductor"), as well as the fact that if the installation consists of only two layers, and the polyolefin-based composition is the inner layer (as is preferred.--see PCT page 5, lines 21-22), it must be in direct contact with a conductor.

(B) "The insulation can consist of a first layer as defined and a second layer as defined."

PCT page 8, lines 10-11, notes that "the insulation consists of two polymeric layers bonded together according to the present invention". While the PCT specification makes it clear that the insulation can comprise more than the two defined layers, it also makes it clear that the simplest embodiment of the invention is insulation consisting of the two defined layers.

(C) "The insulation can be, for example, multiple alternating layers of the first and second polymeric compositions."

See PCT claim 12, which refers to "multiple alternating layers of materials constituting said layers (i) and (ii)"

00015-00039

It appears that no issues arise on these paragraphs.

Amendment of the Claims

As noted above, the independent claims, if they were not already limited to carbonyl-containing polymers having a non-aromatic backbone, have now been so limited.

Claims 29, 38, 48, 63 and 69 have been amended to remove the reference to a process step, and now simply state that the polymers at the interface between the first and second layers are crosslinked.

Claims 72 and 73 have been canceled.

New dependent method Claims 74-75 have been added. They contain substantially the same limitation as claims 31, 32, 46, 60 and 67.

Blends of PVDF and the VDF copolymer

In his comments on RCE (E), the Examiner asked Applicant "to specifically point to support for interpretation of the claims to cover blends of PVDF and VDF".

It is first noted that what the Applicant stated previously, and now repeats (with emphasis added), is that "although the claims no longer refer explicitly to blends of PVDF and the VDF copolymer, the claims do cover such blends **when either the PVDF or the VDF copolymer is present in amount at least 50% by weight**, based on the weight of the second polymeric composition". This statement is no more (and no less) than a statement of the normal rules of construction applied to this feature of the claims. It is included as a precautionary notice to readers of the file history, in order to remove any possibility that a reader might incorrectly understand that the removal of the explicit reference to blends means that all blends are excluded from the claims. The second polymeric component must comprise at least 50% of PVDF or at least 50% of the VDF copolymer. Provided that one of these conditions is fulfilled, the remainder of the second polymeric component can be any polymer (or mixture of polymers). For example, if the second polymeric component contains 80% of PVDF, the other 20% of the second polymeric component can be any polymer, for example a VDF copolymer as defined.

The Rejections under 35 USC 112

6. Applicant respectfully traverses the rejection of claims 28-33, 51-54, 57-61 and 71-73 under 35 USC 112, insofar as that rejection is applicable to the amended claims, for the following reasons.

All the claims now require that the carbonyl-containing polymer has a non-aromatic backbone, thus rendering moot the rejection on the ground that there is no support in the original disclosure for a carbonyl-containing polymer that does not have a non-aromatic backbone.

7. Applicant respectfully traverses the rejection of claims 28-33, 37-40, 42-54, 68-70 and 72-73 under 35 USC 112, insofar as that rejection is applicable to the amended claims, for the following reasons.

As discussed in detail above, in connection with the basis for the "first aspect of the invention" in the specification, it is believed to be clear that there is basis in PCT claim 2, and in the corresponding passage on PCT page 3, for claims in which the weight percentages in the first polymeric composition are based upon the weight of the first polymeric component (as well as support in PCT claim 1 for claims in which the weight percentages are based upon the weight of the whole of the first polymeric composition).

8. Applicant respectfully traverses the rejection of claims 72 and 73 under 35 USC 112, insofar as that rejection is applicable to the amended claims, for the following reasons.

Claim 72 and 73 have been canceled.

The Rejections under 35 USC 103

Applicant respectfully traverses the rejection under 35 USC 103 of

(a) claims 28-32, 37-40, 42, 43, 46, 51-54, 57-67, and 71-73 as unpatentable over WO 97/27260 (hereinafter "Miyaki") in view of U.S. Patent No. 4,693,940 (hereinafter "Vogdes"), and

(b) claims 33, 47-50, 61 and 68-70 as unpatentable over Miyaki in view of Vogdes and US Patent No. 4,804,702 (hereinafter "Bartoszek")

insofar as those rejections are applicable to the amended claims, for the following reasons.

For the sake of completeness, it is noted that similar rejections were made in the Office Action mailed June 18, 2003; that new claims were filed in the reply to the Office Action mailed June 18, 2003; that the Office Action mailed October 20, 2003, stated that those rejections had been overcome by the amendments requested in that Reply; and that there are substantial similarities between the claims filed in the Reply to the Office Action mailed June 18, 2003, and the claims now under examination.

The starting point for each of these rejections is the Miyaki reference. As discussed in detail below, Miyaki has an objective different from Applicant's objective; fails to disclose or suggest the claimed invention; and points away from the claimed invention by making it clear that Miyaki, in order to achieve his objectives, must avoid the use of compositions as defined by Applicant's claims.

Miyaki "has the objective of improving the adhesion of fluorinated resins to metal materials, and of offering a method for obtaining composite materials of metal materials and fluorinated resins" (page 1, lines 33-35). This objective is stated to be achieved through the use of an adhesive composition comprising at least two of (a) a polyvinylidene fluoride (PVDF) resin, (b) an acrylic or methacrylic polymer containing functional groups, e.g. ester groups, for example a polymer containing units derived from methyl acrylate or ethyl acrylate, and (c) a vinylidene fluoride (VDF) copolymer, e.g. a copolymer of vinylidene fluoride and hexafluoropropylene. The acrylic/methacrylic polymer (b) is of course a carbonyl-containing polymer. Miyaki's adhesive composition can be used as an intermediate layer between a metal substrate and an outer layer of a fluorinated resin.

The disclosure of Miyaki's adhesive compositions on page 2, lines 2-10, and in claim 1, does not specify the proportions of the polymers (a), (b) and (c). However, the rest of Miyaki makes it clear that the polymers (a), (b) and (c) must be used in specific proportions, and in particular that the amount of the acrylic/methacrylic polymer (b) must not exceed 50% of the total of the polymers (a), (b) and (c). Thus, Miyaki, Page 3, lines 28-31, states

> *When the metal-adhesive composition contains (a), (b) and (c) components, it contains from 0.5 to 100 parts by weight of an acrylic and/or methacrylic polymer (b), from 1 to 200 parts by weight of vinylidene fluoride copolymer resin (c) per 100 parts by weight of polyvinylidene fluoride resin (a).*

and Miyaki page 4, lines 19- 24, states

> *In particular, in the case where the adhesion process is a melt process, it is preferred that the three component-composition is composed of 5 to 100 parts by weight of the acrylic or methacrylic polymer (b) with bonding properties or affinity in terms of metals and from 10 to 200 parts by weight of vinylidene fluoride copolymer (c) per 100 parts by weight of PVDF resin (a).*

and Miyaki page 7, lines 12-20, states

> *The present invention provides improved binders consisting of the above metal-adhesive compositions:*
>
> *1/ which contains (a) and (b) only, the amount of (b) corresponding to 0.5 to 20 wt% of the total composition*
>
> *2/ which contains (a) and (c) only, the amount of (c) corresponding to 0.5 to 50 wt% of the total composition,*
>
> *3/ which contains (a) (b) and (c) only, the amount of (b) correspond to 0.5 to20 wt% of total composition and the amount of (c) corresponding to 0.5 to 50 wt%...*

and the Examples of Miyaki's invention use less than 20% of the acrylic/methacrylic polymer and provide good results, whereas Miyaki's Comparative Example 1, in which the adhesive composition contains 100 parts of a PVDF resin and 30 parts of the acrylic/methacrylic polymer (i.e. about 23% of the acrylic/methacrylic polymer) provides poor results.

The Office Action states that Miyaki's adhesive composition reads on the first layer of applicant's claims, the component (b) of Miyaki's composition being the first polymeric composition and the first polymeric component. This statement, however, apparently overlooks the fact that, in the claimed invention, the carbonyl-containing polymer must be present in an amount much greater than the 50% maximum set by Miyaki.

Thus, independent claims 28, 37, 47, 51 and 68 (which are directed to the first aspect of the invention) require that the first polymeric component should comprise at least 60%, based on the weight of the first polymeric component, of the carbonyl-containing polymer. This 60% minimum is substantially greater than the 50% maximum which is the outer limit of Miyaki's disclosure, and far, far above the 20% maximum preferred by Miyaki, and in fact demonstrated by Miyaki's Comparative Example 1 to be a practical maximum.

Similarly, independent claims 57, 62 and 71 (which are directed to the second aspect of the invention) require that the first polymeric composition should contain at least 60%, based on the weight of the whole composition, of the carbonyl-containing polymer. Thus if the first polymeric composition also contains other ingredients, the maximum amount of the carbonyl-containing polymer will be less than 60%.

Dependent claims 40 and 64 require that the first polymeric composition contains at least 80% of the carbonyl-containing polymer, and are yet further distinguished from Miyaki.

Independent claims 47 and 68 and dependent claims 31, 32, 46, 60, 67, 74 and 75 require that the polymeric component of the first polymeric composition consists essentially of the carbonyl-containing polymer and polyethylene, thus excluding the possibility that the composition should also contain the PVDF resin or vinylidene fluoride copolymer resin which are essential ingredients of Miyaki's compositions.

Vogdes does nothing to supplement the deficiencies of Miyaki noted above, and appears to be relied upon only for its disclosure of crosslinking. As discussed in detail below, Vogdes

cannot properly be combined with Miyaki , there being no reason why one of ordinary skill in the art, ignorant of the Applicant's invention, would consider Vogdes to be of any value for modifying Miyaki's disclosure.

Vogdes is concerned with the adhesion between two layers of incompatible polymers (one of which may be a VDF polymer), not the adhesion between a metal substrate and a VDF polymer. There is no reason, therefore, why one seeking to modify Miyaki's teaching would regard Vogdes as a useful source of information. It is well-settled law that a rejection cannot properly be based on a combination of references unless there is some reason to read the references together. As the MPEP puts it in 2143.01

> *First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings.*

As the CAFC put it in ACS Hospital Systems vs. Montefiore, 221 USPQ 929

> *Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Under Section 103, teachings of references can be combined **only** if there is some suggestion or incentive to do so.*

The Examiner has not given any reason for combining Vogdes with Miyaki. Nor is there in fact any such reason. On the contrary, there are positive reasons why the references would **not** be read together. Insofar as Miyaki is concerned with articles containing two polymeric layers, each of the layers is composed of a composition containing a VDF polymer, and the polymeric compositions are **explicitly designed to be compatible** with each other. Miyaki's layers are not, therefore, composed of **incompatible** polymers, which is the essential starting point for Vogdes' disclosure. Without knowledge of the present invention, therefore, there is no reason to read Miyaki and Vogdes together.

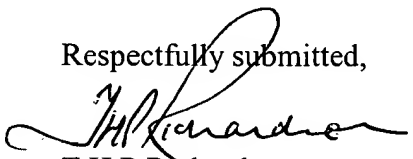
Having regard to the facts and argument set out above, it is believed to be clear that consideration of the tertiary reference (Bartoszek) is not required.

It is believed to be clear, having regard to the facts and arguments set out above, that the rejections under 35 USC 103 should be withdrawn.

CONCLUSION

It is believed that this application is now in condition for allowance, and Applicant respectfully requests that a timely Notice of Allowance be issued in this case. If, however, there are any outstanding issues that could usefully be discussed by telephone, the Examiner is asked to call the undersigned.

Respectfully submitted,



T.H.P.Richardson

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650-854-6304

[00001] BACKGROUND OF THE INVENTION

[00002] This invention relates to insulation for electrical wire or cable.

[00003] Wire and cable with dual wall insulation comprising a polyolefin inner layer and polyvinylidene fluoride (PVDF) outer layer have been commercially available for over 30 years. In such insulated products, the adhesion between the polyolefin and PVDF layers is negligible, and as a result the products suffer from the certain disadvantages.

[00004] SUMMARY OF THE INVENTION

[00005] It has now been discovered, according to the present invention, that ~~improved~~ insulation can be provided by a first layer comprising a first polymeric composition which comprises a ~~selected~~ carbonyl-containing polymer and which is as defined below, and an adjacent second layer comprising a second polymeric composition which comprises a ~~selected~~ fluoropolymer and which is as defined below, these layers being ~~. These layers can be~~ bonded together by cross-linking. The invention makes it possible to achieve high-performance bonding between such layers while retaining an acceptable balance in the complex relationships of other wire performance requirements. T~~o provide insulation having improved performance characteristics in one or more areas such as resistance to abrasion, peeling (especially if one of layers is damaged), blistering (especially if heat is applied), delamination, creasing and wrinkling (especially when the insulation is subject to mechanical stress or exposure to solvents).~~

[00006] In a first aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation comprising

(i) a first layer which is composed of a first polymeric composition consisting of a first polymeric component and optionally a first additive ~~non-polymeric~~ component, the first polymeric component comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric component, ~~(or, in~~

~~some embodiments, based on the weight of the whole composition)~~ of a carbonyl-containing polymer ~~(which~~ which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, ~~and which preferably has a non-aromatic backbone),~~ the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene;

(II) a second layer which is in direct contact with the first layer at an interface, and which is composed of a second polymeric composition consisting of a second polymeric component and optionally a second additive ~~non-polymeric~~ component, the second polymeric component comprising at least 50%, particularly ~~or~~ at least 90%, for example ~~substantially~~ 100%, by weight based on the weight of the second composition, of ~~at least one of~~ polyvinylidene fluoride (PVDF) or ~~and~~ a vinylidene chloride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene chloride, and

(b) repeating units derived from a partially or fully fluorinated co-monomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00007] In a second aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which is composed of a first polymeric composition comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer which has a

non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer, and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene, and

(ii) a second layer which is in direct contact with the first layer at an interface, and which is composed of a second polymeric composition comprising at least 50%, preferably at least 90%, for example 100%, by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a partially or fully fluorinated comonomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00008] Preferably, in each of the first and second aspects of the invention, ~~Preferably,~~ the layers (i) and (ii), while in contact with each other, have been subjected to conditions which cause cross-linking of polymers at the interface between them, preferably by subjecting the layers to radiation, particularly ionising radiation. The cross-linking is preferably such that at least one of the following conditions is fulfilled

(a) the peel bond strength between the layers, measured by ASTM 81876- 95, is ~~to~~ at least 5N, preferably more than 10N,

(b) when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone ~~4.2 mm deep~~ at 23 °C for 1 hour, there is no delamination of the two layers, and

(c) the peel bond strength between the layers after the crosslinking, measured by ASTM B1876-95, is at least 50%, preferably at least 100%, especially at least 500% or 1000%, greater than the peel bond strength between the layers before the crosslinking, measured by ASTM B1876-95.

~~Throughout this specification, including the claims, the terms "a", "an" and "the" before an item mean that there can be a single such item or two or more such items, unless the context makes this impossible (for example, in the first aspect of the invention, the first polymeric component can comprise a single carbonyl-containing polymer as defined or two or more such polymers; and the second polymeric component can contain a single fluoropolymer or a mixture of two or more fluoropolymers); and the term "consisting essentially of" certain ingredients means that those ingredients are necessarily present and that other ingredients may be present providing that their presence does not substantially change the properties of the insulation.~~

[00009] A third ~~second~~ aspect of the invention provides a method of making an insulated wire or cable, the method comprising the steps of

(A) providing an electrical conductor surrounded by

(i) a first layer which is composed of a first polymeric composition as defined in the first or second aspect of the invention; and

(ii) a second layer which is composed of a second polymeric composition as defined in the first or second aspect of the invention;

the first and second layers being in direct contact with each other at an interface, and the first layer being positioned between the conductor and the second layer ~~one~~; and

(B) exposing the layers while in contact with each other to ionising radiation which causes cross-linking of polymers at the interface.

[00010] DETAILED DESCRIPTION OF THE INVENTION

[00011] In some embodiments of the invention, the first polymeric component contains, in addition to ~~When the first polymeric component does not consist solely of~~ the carbonyl-containing polymer, polyethylene, preferably ~~any other polymer present in the first polymeric component is preferably a polyolefin, particularly~~ high-density polyethylene.

[00012] Each of the layers (i) and (ii) optionally contains, in addition to the polymeric component of the composition, an additive component to give the composition required properties. ~~a non-polymeric component comprising additives such as anti-oxidants, pigments, fillers, flame retardants, etc, to enhance mechanical, thermal, electrical etc. properties of the insulation.~~

[00013] Examples of additives which may be present in the first polymeric composition are cross-linking promoters, antioxidants, pigments, fillers, flame retardants, etc. as known per se. Examples of additives which may be present in the second polymeric composition are cross linking promoters, pigments, plasticizers, stabilizers, antioxidants and process aids.

[00014] A convenient method for gauging the bond strength between the layers (i) and (ii), when they have been fabricated onto a wire, is to immerse ~~place~~ a sample wire, of total length 60mm, ~~into~~ in a bath of acetone (e.g. Fisher Scientific UK, AR certified grade acetone), to a depth of 42 mm. ~~acetone equivalent to 70% of the length of sample wire, at 23 (+/- 3)°C, for a period of 1 hour.~~ Wires with negligible bonding of the insulation layers experience an extension of the outer layer, along the axis of the wire, that is independent of any extension of the inner layer, and/or wrinkling of the outer layer such that it delaminates from the inner layer in places. When it occurs, the above-mentioned extension of the outer layer typically results in a "tube" extending for 1mm or more beyond the cut end of the inner layer. Wires with significantly bonded insulation layers experience an extension of both layers without separation, beyond the cut edge of the conductor, along the axis of the wire and/or wrinkling of the two layers together, without delamination. Any such wrinkling of the two layers together can be distinguished from wrinkling only of the outer layer by examining a cross-section of the wrinkles under a microscope.

[00015] In the method of the invention, step (A) can make use of any process which causes intimate contact between the layers (i) and (ii). Examples include coating the second polymeric composition onto a pre-formed layer of the first polymeric composition, and dual or multi-walled extrusion to form insulation layers respectively containing one or other of the polymeric compositions. The layers made from the two different compositions can be coextruded, tandem extruded, multipass extruded, or coated by other means. Known wire insulation processes such as tube draw-down extrusion may be used, to form one or more of the layers, but pressure extrusion as known per se is preferred for optimum adhesion of the second and any subsequent insulation layers to be applied to a pre-formed underlying layer. The first layer can optionally be ~~In some embodiments of the invention, the first layer is~~ in direct contact with the conductor. The insulation can consist of a first layer as defined and a second layer as defined. The insulation can be, for example, multiple alternating layers of the first and second polymeric composition. ~~In some embodiments of the invention, the defined first and second layers are the sole insulation around the conductor. In other embodiments, the first and second layers are part of multilayer insulation including one or more other layers.~~

[00016] In step (B) of the method of the invention, the insulation on the wire is exposed to conditions which cause a cross-linking reaction. The cross-linking may involve chemical reagents such as peroxides, but preferably is effected by radiation, especially radiation from a source of ionising radiation capable of causing the formation of free radicals and thus, cross-links, in the polymers, some of which should preferably be formed in the region of the interface between the two compositions. Penetration of the radiation into the insulation at least as far as the interface is therefore desirable, although not necessarily essential if ion or radical mobility, for example, enables molecular reactions to continue at or near the interface after the radiation process. The radiation source could, for example, be a radio-isotope, or an X-ray source, or possibly a non-ionising radical-generating source, for example a UV source, but is preferably an electron beam, more preferably one providing a beam dose greater than 2 Mrads, preferably at least 5 Mrads, more preferably at least 10 Mrads, very preferably at least 15Mrads, into the material.

[00017] It has been found that, when the cross-linking is effected by ionizing radiation, enhancements to the interfacial bond strength may be obtained by including a cross-linking promoter ("pro-rad") in the first and/or second polymeric composition. Known pro-rads may be used, preferably methacrylate/acrylate based pro-rads, e.g. imethylolpropanetrimethacrylate (TMPTM).

[00018] Experimental results:

[00019] All results quoted in the tables below were obtained by testing pressed plaques of the two materials prepared by the usual polymer handling techniques, well known per se. The plaques were pressed together to bond them face-to-face and the bonded assembly was irradiated as indicated. Plaques were used for these demonstration experiments rather than wires, due to the relative ease of measuring bond strength on plaques. Conditions for these experiments were as follows:

Plaque dimensions: 150mm by 150mm by 0.85mm

Pressing temperature: 200°C

Pressing time: 2 minute preheat, 1 minute at pressure

Pressing pressure: 20-40 Tons over a 300mm by 300mm metal plate

Cooling conditions: 2 minutes between water cooled, 300mm by 300mm, metal plates, at a pressure as above.

[00020] In the Experimental Results shown below, the first composition (comprising the carbonyl-containing polymer) is referred to as the polyolefin-based material and as Material 1, and the second composition is referred to as the PVDF-based material and as Material 2; and the following abbreviations are used (in addition to those already given). EVA is ethylene/vinyl acetate copolymer. VA is vinyl acetate. EEA is ethylene/ethyl acrylate copolymer. EA is ethyl acrylate. EMA is ethylene/methyl acrylate copolymer. MA is methyl acrylate. HDPE is high-density polyethylene. PVDF is polyvinylidene fluoride.

[00021] Example of Effect of Radiation Dose on Bond strength developed between appropriate polyolefin and PVDF-based materials

Material 1	Material 2	Dose(Mrad)	Peel force (N)
EVA copolymer of 25wt% VA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	0	0.5
Same as above	Same as above	15	40
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	0	1
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	8	24
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	20	52
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	0	<5
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	20	21

[00022] Example of Effect of Percentage Comonomer in Ethylene Copolymer Material on bond strength to appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EMA copolymer with 9wt% MA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	4
EMA copolymer with 28wt% MA content	Same as above	20	45

[00023] Example of Effect of percentage Copolymer in a polyolefin polymer blend on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel force (N)
100% HDPE	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	0
20% HDPE + 80% EEA copolymer of 15wt% EA content	Same as above	20	70

[00024] Example of Effect of PVDF-based material type on bond strength with appropriate polyolefin based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EVA copolymer with 25wt% VA content	PVDF homopolymer	15	4
As above	VDF/HFP copolymer of 10wt% HFP content	15	17.5

[00025] Example of Effect of the addition of Pro-rad in Olefinic Material on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
20% HDPE + 80% EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	70
19% HDPE + 77%EEA copolymer of 15wt% EA content + 4% TMPTM pro-rad	Same as above	20	>130

[00026] Examples of Wire Construction

[00027] An electrical wire in which the insulation consists of two polymeric layers bonded together according to the present invention was made as follows:

[00028] The inner layer of insulation (i.e. nearer to the wire conductor) was a polyolefin-based material, consisting predominantly of (a) an EEA copolymer containing 15wt% EA and (b) HDPE in a weight ratio of approximately 8:2 copolymer:HDPE, with usual other additives present in smaller proportions including crosslinking promoters, stabilisers, antioxidants, pigments and process aids at a total level of 24wt%. This layer was pressure extruded onto the metallic conductor.

[00029] The outer layer of insulation consisted predominantly of a PVDF/HFP copolymer containing 10wt% HFP, which in this example contains a crosslinking promoter, and other known additives such as pigments, plasticisers, stabilisers, antioxidants and process aids in usual proportions totalling 7.5wt%. This outer layer was pressure extruded in a separate operation onto the pre-formed inner layer. This coated wire product was then passed through an electron beam, and received a radiation dose of 20Mrads.

[00030] In a second example a wire was made as above, in which the crosslinking promoter in the inner layer was 4% TMPTM, and the the outer layer of insulation was comprised solely of the PVDF/HFP copolymer containing 10wt% HFP. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads. This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00031] In a third example, a wire of the same construction as the second example was made by tandem pressure extrusion of the inner and outer insulation layers. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads.

This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00032] Demonstration of Improved performance of wires constructed as in the second example above, relative to current commercially available wire.

[00033] A wire of the above construction and manufacturing process (designated wire A) was compared with a market leading commercially available polyolefin/PVDF dual-walled wire (designated wire B) of the same dimensions, over a range of tests for wire robustness relevant to harsh handling and end-use environments. The following results were obtained.

[00034] Example of scrape abrasion resistance improvement.

[00035] Method: Equipment=conventional type wire scrape abrader, wire size 0.75mm^2(conductor cross sectional area), blade type flat, width 3.5mm held perpendicular to wire, with 0.05mm radiused edges each side, applied load 1.8kg, stroke length 10cm, at 55 cycles/minute

Wire Type	No. of scrape cycles to abrade through PJ at 40°C
A	>800
B	272

Wire Type	No. of scrape cycles to abrade through PJ at 5°C
A	>1350
B	212

[00036] Example of cold impact resistance improvement.

[00037] Method: wire size 6mm^2(conductor cross sectional area), impact weight 800g, drop height 275mm onto anvil, anvil area impacting on wire of dimensions 7mm x 2mm

widening to 3.4mm via 45° taper each side, ambient temperature 5°C. Visual detection of insulation crack propagation.

Wire Type	Result of cold impact test
A	No cracks in PJ propagate away from site of anvil impact
B	Severe cracks in PJ, >5 mm in length, propagate away from site of anvil impact. PJ starts to peel off core

[00038] Example of solvent resistance improvement.

[00039] Method: wire size 0.75mm^2, length of wire 60mm,acetone immersion length 75% of wire length, immersion time 1hour, temperature 23°C

Wire Type	Result of acetone immersion test
A	No separation/delamination of core and PJ, no cracking of either insulation layer observed
B	PJ wrinkled very severely along immersed length, cracking spontaneously in two places, and exposing 2-3mm of core